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EFFECTS OF SHORT-TERM SAMPLING ON ECOLOGICAL CHARACTERIZATION AND EVALUATION OF EPIGEIC SPIDER COMMUNITIES AND THEIR HABITATS FOR SITE ASSESSMENT STUDIES

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ABSTRACT. Epigeic invertebrates such as spiders are of increasing importance for habitat characterization and for assessments within environmental plannings in Germany and other European countries. Due to high costs for spider sampling (e.g., with pitfall traps), proposals for a limited sampling effort are required for the practical use. The results of a two-year study with continuous sampling are compared to results of short-term sampling and to results of a reduced number of traps. The same data set is used for all evaluations. Decreasing sampling effort generally reduced the number of recorded species and led to a biased ecological characterization of the spider communities. Reducing the number of pitfall traps used provided a more representative sample than did reducing the duration of sampling. In general, errors based on reduced sampling were lower for agricultural than for natural habitats. These results offer practical use of spiders for bioindication in future environmental planning.

The number of epigeic arthropod species which are collected in a specific area depends mainly on the sampling effort, such as on the number of traps or on the length of the sampling period (Stein 1965). One reason for this phenomenon is the finding that rare species or species with short activity periods (but also species living in adjacent habitats) are more likely to be caught with increasing sampling intensity. Therefore, sampling by means of pitfall traps is usually carried out during the entire growing season (in Germany: March–October) and is often repeated in subsequent years to obtain data for a reliable analysis of the species composition of the arthropod community. Unfortunately, there are often limited financial resources for these studies and the results are often required within a short period of time. Therefore, there have been several proposals for a limited investigation program concerning pitfall traps, including the recommendations for sampling periods of only six weeks (Duelli *et al.* 1990) or 10 weeks (Finck *et al.* 1992) or the reduction of the sampling period to only one season (spring or summer; Maelfait & Desender 1990). Alternatively, sampling efforts can be reduced by limiting the number of pitfall traps per habitat.

However, there is little knowledge about the effects of a reduced sampling effort on the quality of the results, and on the conclusions based on these results. This study tests the effects of short term sampling by: (1) comparing data from an eight week trapping period to data from continuous trapping throughout the season (28 weeks; March–October) and (2) analyzing the results obtained by a reduced number of traps. Data are analyzed to examine both the impact of the reduced sampling effort on species numbers and on the ecological characterization of the spider communities of 20 different study sites.

STUDY AREA

This study was conducted in a typical agricultural landscape south of Bonn (North-Rhine-Westphalia, Germany), which is characterized by intensively-used arable land, meadows, orchards and patchily distributed small forests. Semi-natural landscape elements include small river valleys with adjacent wet grassland, small riparian alder forests, river banks and small patches of abandoned formerly wet pastures. A set of 20 different habitats representing the most important habitat types was investigated along two transects across two valleys (transect I near the village of Pech; transect II near the village of Zuellighoven). These transects ranged from semi-natural to agricultural areas.

Table 1.—List of the investigated sites (I = transect I (near the village of Pech), II = transect II (near the village of Zuellighoven), a = additional site).

Code	Transect	Investigation period	Habitat
for1	I	3/90–10/91	beech-oak forest on acid soil with poor herb vegetation
for22	I	3/92–10/93	beech-oak forest on acid soil with poor herb vegetation mixed with *Pinus silvestris* and *Ilex* shrubs
for24	a	3/92–10/93	beech-oak forest on acid soil with poor herb vegetation
alf11	II	3/90–10/91	pastured red alder forest with springs
alf14	II	3/90–10/91	red alder forest with natural flood dynamic
rib5	I	3/90–10/91	shady river bank with red alder riparian forest, mixed with *Prunus padus*
rib13	II	3/90–10/91	river bank with red alder riparian forest partly mixed with *Urtica dioica* stands
rib26	a	3/92–10/93	muddy river bank with red alder riparian forest
rib27	a	3/92–10/93	top of river bank 26 with mesotrophic grassland *Molinio-Arrhenatheretea*-community
pla25	a	3/92–10/93	young plantation of *Quercus petraea,* mixed with blackberry bushes and birch trees on acidic soil
fal18	a	3/90–10/91	mesophilic fallow surrounded by forests, partly covered with blackberry bushes and young trees (aspen)
rib4	I	3/90–10/91	linear red alder riparian forest close to the river bank exposed to the sun with rich tall herb vegetation
wfal2	I	3/90–10/91	wet fallow (*Convolvuletalia*), smaller parts with *Filipendulion*- and *Magnocaricion*-vegetation
wfal17	a	3/90–10/91	wet fallow with sedges, Carex acutiformis-community, *Magnocaricion*
wpas12	II	3/90–10/91	wet pasture with *Juncus effusus*
pas7	I	3/90–10/91	intensively managed mesophilic pasture *Lolio-Cynosuretum*
pas15	II	3/90–10/91	intensively managed mesophilic pasture *Lolio-Cynosuretum*
pas19	a	3/90–10/91	intensively managed mesophilic pasture *Lolio-Cynosuretum* with apple trees, surrounded by forests
field10	II	3/90–10/91	extensively managed crop field with rich stands of weeds, *Aphano-Matricarietum*
field8	I	3/90–10/91	intensively managed crop field with poor or no weeds

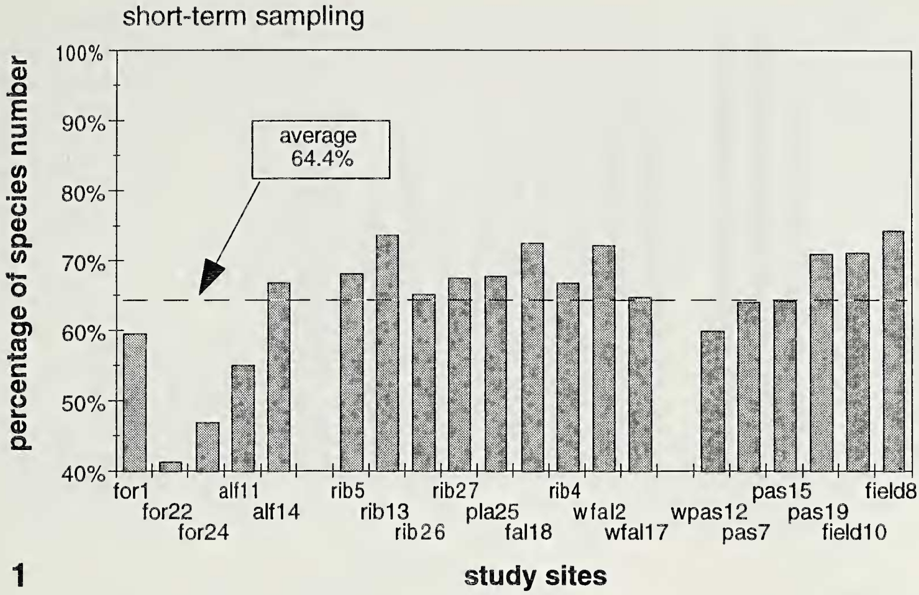
Additionally, some samples were collected in adjacent localities with characteristic habitat types not covered within the transects (Table 1; for details see Riecken 1998).

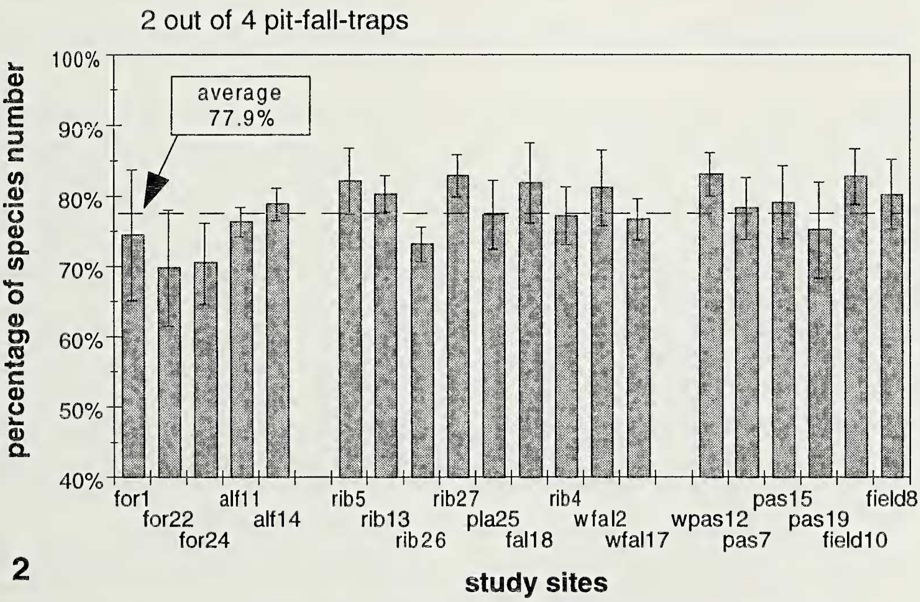
METHODS

Spiders were sampled by means of pitfall traps (350 ml honey-glasses, opening diameter 7 cm), filled with 125 ml of formaldehyde solution (2%) and protected by a roof of a clear acrylic plastic (20 cm × 20 cm). Four traps were exposed at each site (in line, distance 5 m) for two years (for two different periods: 1990, 1991, and 1992, 1993 March to October every year; Table 1). All traps were emptied every two weeks.

Duelli *et al.* (1990) originally proposed two sampling periods of five weeks a year, with the traps being emptied once a week. Further analysis should include only data from those three weeks of each period during which the greatest number of specimens were caught. In this study, traps were emptied every two weeks. As it was impossible to take data from three-week periods, two four-week periods seemed to be a good approximation of Duelli's method. Applying this protocol for a limited sampling period resulted in a short-term data set for the following time periods (two four-week periods from both years): sites investigated 1990 and 1991 (see Table 1): 18 May–12 June 1990, 9 August–5 September 1990, 16 May–11 June 1991 and 8 August–5 September 1991; sites investigated 1992 and 1993 (see Table 1): 21 May–16 June 1992, 13 August–9 September 1992, 19 May–15 June 1993 and 12 August–8 September 1993.

Parametric *t-tests* were used for compari-





Figures 1, 2.—Percentage of species numbers in different sampling protocols. 1. Results from a short-term sampling (eight weeks a year); 2. Results from a reduced data set (average species number from all possible pairs of two out of four pitfall traps) in comparison to the complete data set from sampling throughout two growing seasons (March to October) and all traps.

sons of percentage values (Jongman *et al.* 1987). All data sets were tested for a normal distribution.

All comparisons were made between the results of the complete data set over two seasons (28 weeks each = 100%) and reduced data sets. I first compared the results from two four-week periods (short-term sampling), and then the results of a reduced number of pitfall traps. In the case of the reduced trap numbers,

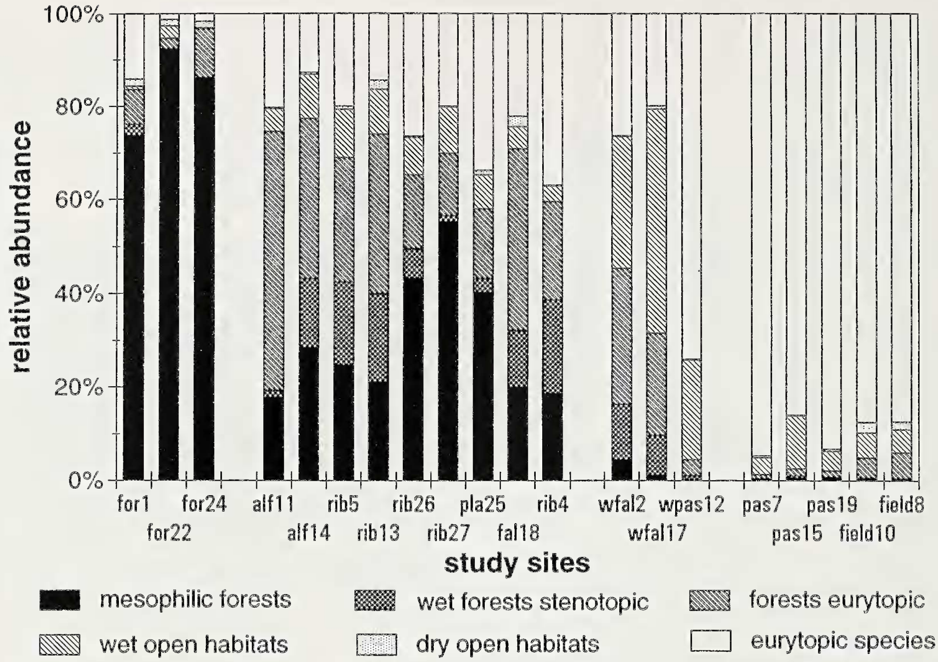


Figure 3.—Composition of the spider communities based on classification of habitat affinity.

the arithmetic means of the results for each trap (n = 4) or each possible pair of traps (n = 6) were calculated (bars in Figs. 2 and 5).

Habitats were classified by a cluster analysis based on the percentage similarity (Renkonen 1938), using the computer program COMM (Piebenburg & Piatkowski 1992) and the "unweighted pair group method using arithmetic means" (UPGM-linkage). In this method, the distances between clusters are calculated from arithmetic means of the distances between the objects within the compared clusters (Legendre & Legendre 1983).

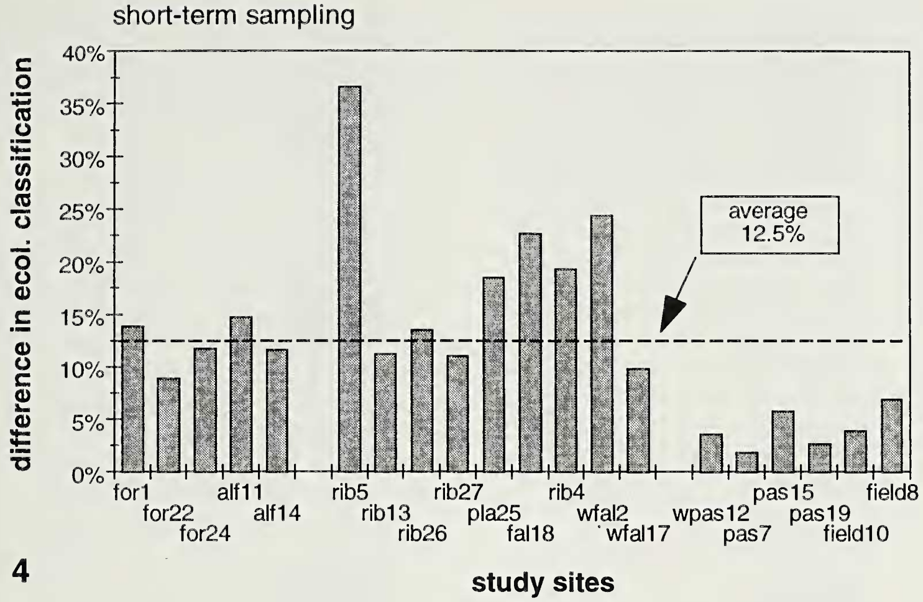
RESULTS

A general analysis, based on a total catch of 50,471 adult spiders belonging to 169 species, showed that Linyphiidae (75.4% of all specimens) and Lycosidae (18.3%) were the most abundant families. Agelenidae (2.3%), Tetragnathidae (1.9%), and Amaurobiidae (1.6%) also occurred regularly. The remaining 17 families comprised only 1.5% of the total catch, but 27% of the recorded species.

Influence of short-term sampling and number of pitfall traps on species numbers.—In the present study, a short-term trapping period as proposed by Duelli et al. (1990) would have reduced the number of recorded species to 64.4% of the initial sample (Fig. 1). In two habitats (forest 22 and 24), less than 50% of all species were included. By contrast, the reduced data set from the intensively used pasture 19 and from the fields contained more than 70% of all species recorded there.

If data from only two of four pitfall traps were used (i.e., a reduction of number instead of time), a significantly higher proportion ($P < 0.001$) of species was included (on average 77.9% of the total number; Fig. 2) in comparison to Duelli's proposal. Even in the worst case (forest 22 and 24), approximately 70% of all species were included.

Influence of reduced data sets on the ecological characterization of the spider communities.—Bioindication or planning processes related to nature conservation often require a classification of the habitat preferences or ecological characters of the recorded species. To determine whether a reduced data set would have an impact on ecological characterization of the spider communities, all species were classified based on literature data (Hänggi *et al.* 1995; Platen *et al.* 1991; Reinke & Irmler 1994; Roberts 1985, 1987, 1995; for further details, see Riecken 1998). The following six habitat affiliations were distin-



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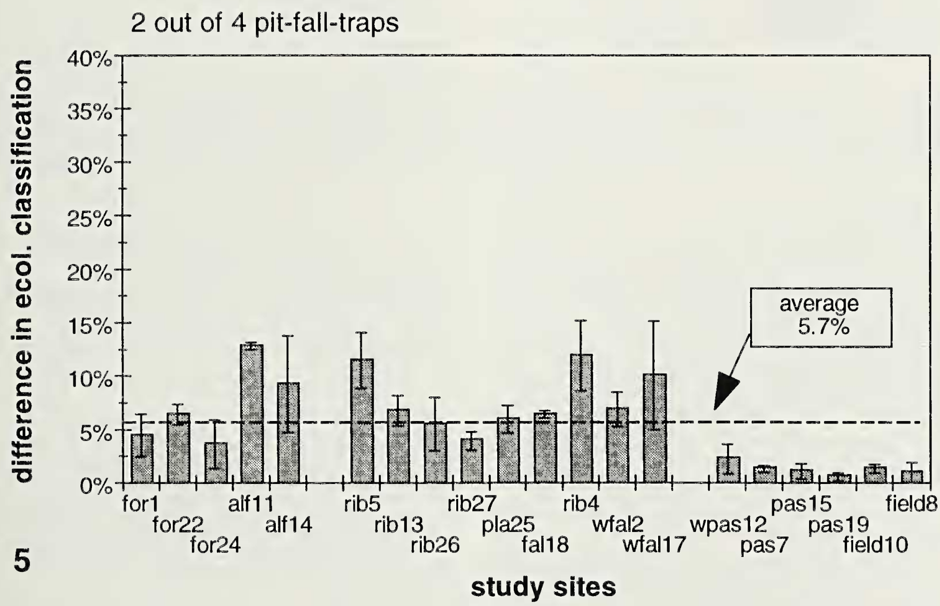

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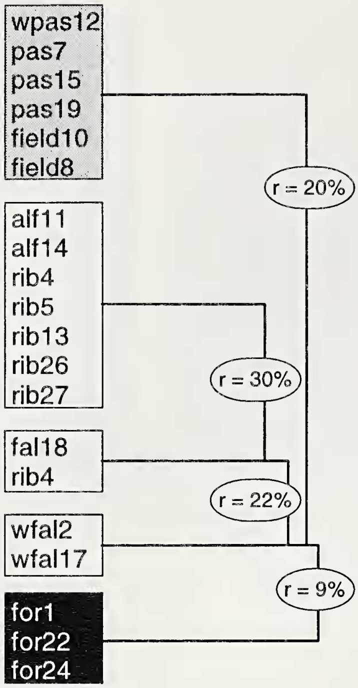
Figures 4, 5.—Summarized differences (percentage dissimilarities) in relative abundance of six types of habitat affinity. 4. Affinity resulting from a short-term sampling in comparison to the complete data set from sampling throughout two growing seasons (March–October) and all traps; 5. Affinity resulting from a reduced pitfall number (average of all possible pairs of two out of four pitfall traps).

guished: (1) species restricted to mesophilic forests, (2) species restricted to wet forests, (3) species preferring forests without being restricted to them, (4) species preferring wet open habitats such as bogs, grassland or shores, (5) species preferring dry open habitats, such as meadows or heathers, and (6) eurytopic species that cover a broad range of open habitats, e.g., all types of meadows, fields and fallows. Based on these classification, the community compositions were determined (Fig. 3).



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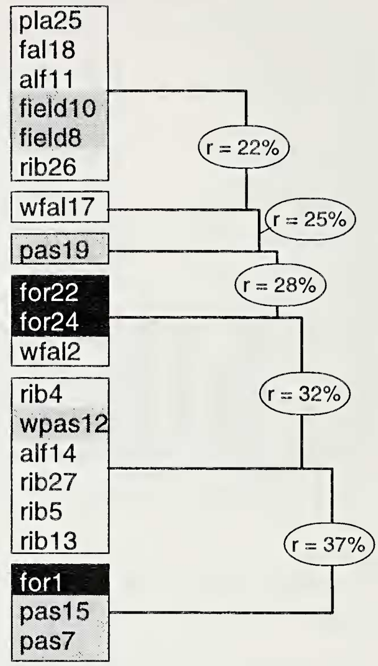

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Figures 6, 7.—UPGM-linkage dendrogram based on the "percentage similarity" (RENKONEN-index) classifying the study sites (r = resemblance). 6. Similarities based on the complete data set from sampling throughout two growing seasons; 7. Similarities based on data resulting from short-term sampling.

The dissimilarities (based on the ecological classifications) between short-term data sets and the full data set varied between 1.7% (pasture 7) and 36.6% (river bank 5). The average dissimilarity (pooling all sites) was 12.5% (Fig. 4). When analyzing only 1 out of 4 pitfall traps, the dissimilarities varied between 1.0% (pasture 19) and 20.4% (river bank 4), with an average of 9.6% for all sites. This result did not differ significantly from short-term sampling ($P > 0.05$). Considering data from two pitfall traps (Fig. 5), the results were significantly more similar to the complete data set than the results from short-term sampling were ($P < 0.001$). Here, the dissimilarities varied between 0.6% (pasture 19) and 12.8% (alder forest 11), with an average of 5.6%.

There are two major reasons for the relatively high dissimilarities resulting from a reduced sampling period: the phenology of the dominant species and, depending on it, the differences in phenology of ecological types. Thus, the spider communities are dynamic during the season, both in species composition and in the relative abundance of ecological types. Therefore, different results can be expected depending on the time frame for sampling, leading to assessment errors and inappropriate nature conservation measures based on bioindication.

In general, errors based on reduced sampling were lower for agricultural habitats (pastures, fields) than for semi-natural sites. The main reason for this finding is the generally low percentage of stenotopic species in all pastures and fields (except the wet pasture 12, see Fig. 3).

Influence of short-term sampling on coenotic comparisons.—The results were also strongly influenced by short-term sampling when different spider coenoses were compared by cluster analysis (UPGM-linkage) based on the "percentage similarity" index (Renkonen 1938). Using the complete data set, five clusters of habitats could be distinguished at a similarity level > 40% (Fig. 6). This result confirms the expected pattern based on the studied habitat types. For example, all forests and all agricultural sites were clustered together. The reduced data set, however, produced a completely different result. Even the three quite similar forest sites or the pastures were grouped to different clusters then.

CONCLUSIONS

Short-term sampling reduces the number of recorded species by as much as 50% of the full set. An ecological characterization based on these results is weak, as is a characterization based on a reduced number of pitfall traps, taking only one out of four traps. In contrast to results for carabid beetles (Maelfait & Desender 1990), this reduced data set also leads to important failures in habitat classification and habitat differentiation. Consequently, there will be considerable errors in site assessment. Also, conclusions for planning or for nature conservation activities will be biased if these results are used. Short-term sampling seems to be acceptable only in agricultural habitats. Site assessment studies of epigeic spiders should be carried out throughout the whole growing season (in Germany: March–October). If financial resources are limited, a reduction of the number of pitfall traps will be more appropriate than a reduction of the sampling period.

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LITERATURE CITED

Duelli, P., M. Stader & E. Katz. 1990. Minimalprogramme für die Erhebung und Aufbereitung zooökologischer Daten als Fachbeiträge zu Planungen am Beispiel ausgewählter Arthropodengruppen. Schriftenreihe Landschaftspflege und Naturschutz, 32:211–222.

Finck, P., D. Hammer, M. Klein, A. Kohl, U. Riecken, E. Schröder, A. Ssymank & W. Völkl. 1992. Empfehlungen für faunistisch-ökologische Datenerhebungen und ihre naturschutzfachliche Bewertung im Rahmen von Pflege- und Entwicklungsplänen für Naturschutzgroßprojekte des Bundes. Natur + Landschaft, 67 (7/8):329–340.

Hänggi, A., E. Stöckli & W. Nentwig. 1995. Lebensräume mitteleuropäischer Spinnen.-Charakterisierung der Lebensräume der häufigsten Spinnenarten Mitteleuropas und der mit diesen vergesellschafteten Arten. Centre suisse de cartographie de la faune, Neuchatel (= Miscellanea Faunistica Helvetiae, 4), 459 pp.

Jongmann, R.H. Ter Braak, C.J.f. & O.f.R. van Tongeren. 1987. Data Analysis in Community and Landscape Ecology. Centre f. Agricultural Publ. and Document. (PUDOC), Wageningen. 299 pp.

Legendre, L. & P. Legendre. 1983. Numerical Ecology. Elsevier, Amsterdam. 419 pp.

Maelfait, J.-P. & K. Desender. 1990. Possibilities of short-term Carabid sampling for site assessment studies. Pp. 217–225. *In* The Role of Ground Beetles in Ecological and Environmental Studies (N.E. Stork, ed). Intercept, Andover, Hampshire.

Piepenburg, D. & U. Piatkowski. 1992. A program for computer-aided analyses of ecological field data. CABIOS, 8(6):587–590.

Platen, R., M. Moritz & B.v. Broen. 1991. Liste der Webspinnen-und Weberknechtarten (Arach.: Araneida, Opilionida) des Berliner Raums und ihre Auswertung für Naturschutzzwecke (Rote Liste). Landschaftsentwicklung und Umweltforschung, S 6:169–205.

Reinke, H.-D. & U. Irmler. 1994. Die Spinnenfauna (Araneae) Schleswig-Holsteins am Boden und in der bodennahen Vegetation. Faun.-ökol. Mitt., Suppl. 17:1–148.

Renkonen, O. 1938. Statistisch-ökologische Untersuchungen über die terrestrische Käferwelt der finnischen Bruchmoore. Ann. Zool. Soc. Zool.-Bot. Fennica "Vanamo", 6:1–231.

Riecken, U. 1998. The importance of semi-natural landscape structures in an agricultural landscape as habitats for stenotopic spiders. *In* Proceedings of the 17th European Colloquium of Arachnology, Edinburgh 1997:301–310.

Roberts, M.J. 1985. The Spiders of Great Britain and Ireland. Vol. 1: Atypidae to Theridiosomathidae. Harley Books, Colchester. 229 pp.

Roberts, M.J. 1987. The Spiders of Great Britain and Ireland. Vol. 2: Linyphiidae and Check List. Harley Books, Colchester. 204 pp.

Roberts, M.J. 1995. Spiders of Britain & Northern Europe. Collins, New York. 383 pp.

Stein, W. 1965. Die Zusammensetzung der Carabidenfauna einer Wiese mit stark wechselnden Feuchtigkeitsverhältnissen. Z. Morph. Ökol. Tiere, 55:83–89.

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